Characteristics and Treatment of Primary Mediastinal Seminomas: A Single-center Report of 27 Cases

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Research

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Abstract

Background: The low incidence of primary mediastinal seminomas has precluded the development of clinical trials on mediastinal seminomas. We evaluated the characteristics, treatments, and prognosis of patients with primary mediastinal seminoma.

Methods: We retrospectively collected data on the clinicopathologic characteristics, treatments, toxicities, and survival of 27 patients from a single center between 2000 and 2018. Mediastinal lymph node staging for lung cancer and Masaoka staging for thymic neoplasms were used for disease characterization. Survival was assessed using the Kaplan-Meier method. Univariate analysis was performed using the log-rank test.

Results: The median age was 28 (13-63) years. The most common symptoms were chest pain (29.6%), cough (25.9%), and dyspnea (22.2%). Twenty-four patients showed tumor invasion into adjacent structures. Seven and two patients were diagnosed as having lymph node metastasis and distant metastasis, respectively, whereas 48.1% of patients were diagnosed as having Masaoka stage IIIb disease. Sixteen patients (59.3%) had undergone radiotherapy, whereas 25 (92.6%) had undergone chemotherapy. The most widely used chemotherapy regimens were bleomycin, etoposide, and cisplatin. The median follow-up period was 32.23 (2.7-198.2) months. At 5 and 10 years, the rates of local regional relapse-free survival were 90.9% and 90.9%; overall survival, 100.0% and 80.0%; progression-free survival, 86.4% and 86.4%; distant metastasis-free survival, 95.2% and 95.2%; and cancer-specific survival, 100.0% and 100.0%, respectively.

Conclusions: Primary mediastinal seminoma was frequently diagnosed in patients with tumor invasion into adjacent structures. Chemotherapy was the most widely used treatment. The disease was sensitive to chemoradiotherapy, and the prognosis was favorable.

Background

Primary mediastinal germ-cell neoplasms are rare neoplasms. Mediastinal seminoma accounts for approximately 10-16% of mediastinal germ-cell neoplasms and 0.5-5% of all mediastinal tumors[1,2]. This low incidence has precluded the development of randomized clinical trials on mediastinal seminoma, and present knowledge is based on case reports and very small studies, mostly with sample sizes of 1-16 patients. Furthermore, previous studies included patients with other germ-cell subtypes despite the many distinctive features of seminomas and nonseminomas[3-5] and therefore it is difficult to draw definite conclusions from those studies.

Thus, in this study, we investigated the clinicopathologic characteristics, treatments, and prognosis of patients with primary mediastinal seminomas from a single center.

Methods

Patient Selection

This retrospective study was approved by the institutional ethics committee of our institution. We examined the medical reports of patients treated at the National Cancer Center, Beijing, China, between January 2000 and December 2018. We identified 30 patients with a pathologic diagnosis of mediastinal seminoma in the database. However, one patient was excluded because of incomplete data and two were excluded for having mixed germ-cell neoplasms. Thus, 27 patients were finally included.

Clinicopathologic Variables

Data regarding patient demographics, symptoms, tumor size, history of smoking and alcohol use, invasion status, treatment protocols, and survival were collected. For all cases, physical examination and chest and abdominal computed tomography (CT) were performed before treatment. Ultrasound of the testicles was also performed in all male patients to rule out gonadal involvement.

The sporadic incidence of primary mediastinal seminomas has also contributed to the preclusion of development of a staging system. To describe the extent of invasion and explore the prognosis of patients with primary mediastinal seminoma, we adopted the Masaoka staging system, which is widely used for another mediastinal tumor, that is, thymic neoplasms [6]. To characterize the invasive sites of the mediastinal seminoma, we reviewed the primary CT scans and described the invasive regions according to the International Association for the Study of Lung Cancer (IASLC) mediastinal lymph node system[7].

Outcomes and Statistical Analyses

Tumor response was initially assessed by a senior radiologist and a radiation oncologist and then confirmed by certain investigators for 1 month after treatment, according to the Response Evaluation Criteria in Solid Tumors (RECIST), version 1.1. Treatment toxicities were graded according to the National Cancer Institute Common Terminology Criteria for Adverse Events version 4.0. Overall survival (OS) was defined as the time from diagnosis to death, and progression-free survival (PFS) was defined as the time from diagnosis to disease progression or death. Local-regional relapse-free survival (LRFS) was defined as the time from diagnosis to local-regional recurrence, whereas distant metastasis-free survival (DMFS) was defined as the time from diagnosis to any new distant metastasis. Cancer-specific survival (CSS) was defined as the time from diagnosis to cancer-induced death. Survival curves were plotted using the Kaplan-Meier method. Univariate analysis was performed using the log-rank test and included the following variables: Eastern Cooperative Oncology Group performance status score (ECOG PS), sex, age, Masaoka stage, histology, great vessel (aorta, pulmonary artery, pulmonary vein, or brachiocephalic vein) invasion, R0 resection, radiotherapy, and chemotherapy; $p<0.05$ was considered statistically significant. All statistical analyses were conducted using SPSS 23.0 software (IBM Corp., Armonk, NY).

Results

Clinical Characteristics

The median age was 28 (13-63) years. The median maximum primary tumor diameter was 9.9 (3.3-15) cm. The most common symptom was chest pain. Station 3A was the most common site of invasion. Adjacent tissue invasion was also very common. Most patients were diagnosed with Masaoka stage III-IV disease. Details of patient characteristics are listed in Table 1.

Table 1
Patients' characteristics

Characteristic	N	%	Characteristic	N	%
Sex			Primary tumor invasive site		
Male	26	96.3	1R	5	18.5
Female	1	3.7	1L	5	18.5
Age, years			2R	11	40.7
≤18	7	25.9	2L	11	40.7
>18	20	74.1	3A	27	100.0
First symptom			3P	6	22.2
Dyspnea	6	22.2	4R	11	40.7
Chest pain	8	29.6	4L	11	40.7
Cough	7	25.9	5	14	51.9
Vomit	1	3.7	6	19	70.4
Facial edema	2	7.4	7	4	14.8
Symptomless	3	11.1	8	0	0.0
SVCS			9R	1	3.7
Yes	10	37.0	9L	2	7.4
No	17	63.0	10R	1	3.7
ECOG PS score			10L	4	14.8
0	3	11.1	PDL	2	7.4
1	24	88.9	Invaded adjacent tissue		
Alcohol use			Aorta	15	55.6
Yes	1	3.7	PA	8	29.6
No	26	96.3	SVC	15	55.6
Smoking			PV	3	11.1
Yes	5	19.5	BV	5	18.5
No	22	81.5	AV	1	3.7
Maximum diameter, cm			CA	2	7.4
≤5	2	7.4	CV	1	3.7

5.1-10	14	51.9	Lung	12	44.4
>10	11	40.7	Pericardium	13	48.1
Adjacent tissue invasion			Heart	2	7.4
Yes	24	88.9	Bronchus	1	3.7
No	3	11.1	Trachea	1	3.7
Great vessel invasion			Sternum	2	7.4
Yes	20	74.1	Masaoka stage		
No	7	25.9	I	2	7.4
Lymph node metastasis			II	1	3.7
Yes	7	25.9	IIIa	4	14.8
No	20	74.1	IIIb	13	48.1
Distant metastasis			IVa	0	0.0
Yes	2	7.4	IVb	7	25.9
No	25	92.6			

AV, azygos vein; BV, brachiocephalic vein; CA, carotid artery; CV, carotid vein; ECOG PS, Eastern Cooperative Oncology Group performance status; PA, pulmonary artery; PDL, pericardial diaphragmatic lymph node; PV, pulmonary vein; SVC, superior vena cava; SVCS, superior vena cava syndrome.

Laboratory and Immunohistochemical Characteristics

Human chorionic gonadotropin (hCG) and lactate dehydrogenase (LDH) levels were assessed in 16 and 11 patients, respectively, before treatment and the respective observed values were 21.48 (0.2-900.0) IU/mL and 226 (0.68-1029) ng/mL. Among them, hCG and LDH levels increased in 14 and 5 patients, respectively. After treatment, hCG and LDH levels were reassessed in 22 and 16 patients, respectively. All results were normal, with corresponding median values of <0.1 IU/mL and 168 (122-240) ng/mL.

Immunohistochemical characteristics evaluated according to different HE expressions to achieve diagnostic accuracy (Table 2) revealed high positivity rates for PLAP, OCT3/4, and SALL4.

Table 2
Immunohistochemical results

Antibody	No. of Patients		Antibody	No. of Patients	
	Positive	Negative		Positive	Negative
AE1/AE3	6	10	CK8/18	0	2
AFP	0	8	D2-40	1	1
CD3	0	8	EMA	0	2
CD5	1	3	HMB45	0	3
CD20	0	7	hCG	0	6
CD99	0	1	LCA	0	15
CD30	0	12	Melan-pan	0	2
CD117	14	1	NSE	0	2
CD163	1	0	OCT3/4	5	0
CEA	1	2	P63	0	1
CgA	0	2	PAX5	0	2
ChA	0	2	PLAP	18	0
CK5	0	1	SALL4	6	0
CK7	1	1	Syn	0	4
CK18	2	0	TdT	0	6
CK19	2	3	TTF-1	0	3
CK34βE12	0	1	Vimentin	1	4
CK5/6	0	2			

Treatments

Surgery, radiation, and chemotherapy were administered in 13, 16, and 25 patients, respectively. For three-dimensional conformal radiotherapy or more advanced techniques, the following target volume delineation principles were adhered to. The gross tumor volume (GTV) included the primary tumor and was determined by thoracic CT. The clinical target volume (CTV) included the GTV plus a 5-mm margin and regions of invasion. The planning target volume was created by adding an additional 5-mm margin to the CTV. Among the 25 patients who received chemotherapy, 22 received bleomycin, etoposide, and cisplatin (BEP). Details were listed in table 3.

Table 3
Treatment details

	N	%		N	%
Treatment			Radiation dose(gray)	42.3 (25.2-56.0)	
CHT	2	7.4	Radiation technique		
CRT	12	44.4	2D	4	14.8
CSR	1	3.7	3DCRT	3	11.1
S	2	7.4	IMRT	7	25.9
SCHT	7	25.9	VMAT	2	7.4
SCRT	3	11.1	CHT regimen		
Resection			BEP	22	81.5
R0	9	33.3	EP	1	3.7
R2	4	14.8	CEP	1	3.7
No	14	51.9	PEP	1	3.7
RT			CHT cycle		
Yes	16	59.3	2	2	7.4
No	11	40.7	3	2	7.4
CHT			4	13	48.1
Yes	25	92.6	6	8	29.6
No	2	7.4			

2D, two-dimensional conformal technique; 3DCRT, three-dimensional conformal radiotherapy; CHT, chemotherapy; CRT, chemoradiotherapy; CSR: chemotherapy□radiotherapy and surgery. IMRT, intensity-modulated radiotherapy; RT, radiotherapy; S, surgery; SCHT,surgery plus cheomotherapy; SCRT, surgery plus chemoradiotherapy; VMAT, volumetric modulated arc therapy.

Toxicities

Grade 3 toxicities were observed in four patients (14.8%) (Table 4). Meanwhile, grade 3 hematological and nonhematological toxicities were observed in four patients (14.8%) and 2 patients (7.4%), respectively.

Table 4
Toxicities

	Grade 1	Grade 2	Grade 3	Total
RP	5 (18.5)	0	0	5(18.5)
Esophagitis	1 (3.7)	0 (0.0)	0 (0.0)	1 (3.7)
Dermatitis	11 (40.7)	0 (0.0)	0 (0.0)	11 (40.7)
Vomit	3 (11.1)	5 (18.5)	2 (7.4)	10 (37.0)
Hair loss	6 (22.2)	16 (59.3)	0 (0.0)	22 (81.5)
Leucopenia	10 (37.0)	7 (25.9)	2 (7.4)	19 (71.4)
Neutropenia	8 (29.6)	7 (25.9)	3 (11.1)	18 (66.7)
Anemia	0 (0.0)	1 (3.7)	0 (0.0)	1 (3.7)
Thrombopenia	1 (3.7)	0 (0.0)	0 (0.0)	1 (3.7)

RP, radiation-induced pneumonitis.

Tumor Response

Among the 25 patients who received chemotherapy, 19 achieved a partial response (PR), 1 had stable disease, and 5 had no application since chemotherapy was used as adjuvant therapy. Of the 16 patients who received radiotherapy, 2 and 14 patients achieved complete response (CR) and PR, respectively. After all treatments, CR (including R0 resection) and PR were observed in 40.7% and 59.3% of patients, respectively.

Survival

The median follow-up period was 32.23 (2.7-198.2) months. At the last follow-up, two patients died, neither of whom died of seminoma. One of them died of pneumonitis, and the other died of myocardial infarction. Two patients experienced local recurrence, whereas one patient had distant metastasis.

The median survival times were not achieved. The 5-year and 10-year survival rates were: OS, 100.0% and 80.0%; CSS, 100.0% and 100.0%; LRFS, 90.9% and 90.9%; DMFS, 95.2% and 95.2%; and PFS, 86.4% and 86.4%, respectively. The survival curves are shown in Fig. 1*A-E*.

Prognostic Factors

As none of the patients died from seminoma at the last follow-up, univariate analysis of OS and CSS was not performed. On univariate analysis, patients with superior vena cava syndrome (SVCS) showed a better PFS. Sex was also associated with PFS. Furthermore, patients with distant metastasis at first diagnosis were more likely to have a new distant metastasis than those without distant metastasis at first diagnosis (Fig. 2*A-C*).

For patients with Masaoka stage I-II, III, and IV disease, the 10-year survival rates were LRFS, 100%, 86.5%, and 100% (p=0.600); DMFS, 100%, 100%, and 80.0% (p=0.202); and PFS, 100.0%, 86.5%, and 80.0% (p=0.772), respectively (Fig. 3*A-C*, Table 5). None of the single treatment were associated with survivals.

Table 5
Prognostic factors

Prognostic Factor	10-year LRFS (%)			10-year DMFS (%)			10-year PFS (%)		
	Yes	No	p	Yes	No	p	Yes	No	p
Male	90.8	100	0.838	100	0.00	0.000	90.8	0.0	0.002
Age<18 years	75.0	95.2	0.251	100	94.1	0.628	75.0	85.3	0.943
Symptoms	89.5	100	0.569	94.4	100	0.683	84.2	100	0.801
SVCS	100	84.8	0.238	100	92.3	0.433	100	77.8	0.011
Alcohol use	90.8	100	0.838	95.2	100	-	86.3	100	0.838
Smoking	100	88.7	0.472	100	94.1	0.628	100	83.0	0.620
GVI	93.3	83.3	0.352	100	83.3	0.114	93.3	66.7	0.307
Diameter, >10 cm	100	83.6	0.194	90.0	100	0.294	90.0	83.6	0.407
LNM	100	88.1	0.419	80.0	100	0.704	80.0	88.1	0.602
DMPD	100	90.3	0.706	50.0	100	0.002	50.0	90.3	0.097
Masaoka stage III-IV	90.0	100	0.651	94.7	100	0.746	87.0	100	0.574
R0 resection	100	86.3	0.305	87.5	100	0.202	87.5	86.3	0.715
Surgery	91.7	90.0	0.948	90.9	100	0.340	82.5	90.0	0.245
Radiotherapy	93.3	87.5	0.797	92.3	100	0.433	85.6	87.5	0.236
Chemotherapy	90.5	100	0.755	95.0	100	0.823	100	85.7	0.188

DMFS, distant metastasis-free survival; DMPD, distant metastasis at the primary diagnosis; GVI, great vessel invasion; LNM, lymph node metastasis; LRFS, local-regional relapse-free survival; PFS, progression-free survival; SVCS, superior vena cava syndrome.

Discussion

Mediastinal seminomas are difficult to depict because of their rarity. In this study, we investigated a relatively large number of patients with primary mediastinal seminomas. Seminomas are different from other common thoracic malignancies [8,9] in that neither smoking nor alcohol use is a high-risk factor for the disease. Indeed, 81.5% of the patients in our study were nonsmokers and 96.3% reported no history of alcohol use.

Seminomas mostly occur in men, usually young patients. In our study, the median age was 28 years, which is consistent with that in previous reports (28-34 years) [3,10]. There have been only a few case reports on female patients [2,6,10]. Our study included a woman aged 44 years with pericardial invasion. She underwent R0 resection and postoperative chemoradiotherapy and survived until the last follow-up (8.9 months) with pleural metastasis. Although data showed inferior PFS and DMFS, it is difficult to appropriately determine the relationship between sex and survival rates.

Seminomas usually show slow growth and have an invasive course, although the disease is often asymptomatic at onset. The absence of symptoms leads to disease diagnosis at a more advanced stage because most patients do not seek medical attention until symptom manifestation. The most common symptoms in our study are consistent with those observed in previous studies, with chest pain (14.3-44%), cough (14.3-38%), and dyspnea (14.3%-38%) being the top three symptoms[3,10,11]. During diagnosis, only 11.1% of the patients in our study were asymptomatic, which is almost equivalent to that reported in previous studies (6-40%)[3-5,10].

Due to their slow growth, most seminomas are bulky when diagnosed. The median maximum diameter of the primary tumor (9.9 cm) is consistent with previous findings (8-12 cm) [3,10,11]. The tumor may extend to the mediastinum, leading to compression of adjacent structures and invasion, especially into the great vessels in the mediastinum, such as the SVC and aorta. In our study, 37% of patients were found to have SVCS, which is consistent with the findings of previous reports (10-57%) [3,4,10,11]. However, there was no mention of invasion into the aorta in these previous studies, which might cause difficulties in R0 resection.

In this study, the perivascular station was the most common invasion site (100%), followed by the para-aortic station (70.4%) and subaortic station (51.9%). These results are similar to those of previous studies, which found that mediastinal seminomas are usually located in the anterior mediastinum and in front of the aorta [11].The other common invasion sites were the bilateral lower paratracheal station (40.7%,40.7%) and bilateral upper paratracheal station (40.7%, 40.7%).

The results regarding the IHC characteristics of patients varied. The positivity rate for PLAP was 70.7% in a previous study [12]. In our study, all 18 patients who underwent the PLAP test were PLAP-positive. The positivity rates of OCT3/4, SALL4, and CD117 were also high. This suggests that PLAP could be the most remarkable marker for mediastinal seminoma.

Previous studies have reported elevated β-hCG levels in 0-85.7% of patients with primary mediastinal seminoma [3-5,10]. In our study, 51.8% of patients showed increased β-hCG levels, which is similar to the

findings of a previous study [11]. Such elevated levels might be attributed to tumor enlargement. Meanwhile, serum LDH was not a typical marker of the disease, which is consistent with previous results [3,11].

There is no established staging system for mediastinal seminomas, and the testicular seminoma staging system cannot be used either. However, mediastinal seminomas seem to share some homogeneous characteristics with thymic neoplasms. Both are prevascular tumors and occur in the anterior mediastinum, both are with rare lymph node metastasis and both are associated with a good prognosis. On the basis of these common aspects, we adopted the Masaoka staging system, which is widely used for thymic neoplasms, to evaluate the status of mediastinal seminomas [6,11]. We found that 88.9% of patients were diagnosed as having Masaoka stage III-IV disease. Lymph node metastasis and distant metastasis, on the other hand, are not as common as great vessel invasion. A previous study found that lymph node metastasis occurred in 2.6-38% of patients [10]. Although these findings indicate no significant differences in the prognosis of patients with different Masaoka stages, we found a trend that patients with stage I-II disease exhibited higher DMFS and PFS.

In the univariate analysis, patients with SVCS demonstrated better PFS, which contradicted our current notion that tumor invasion into the great vessels is a worse prognostic factor. Possible reasons are: first, the occurrence of SVCS symptoms led the patient to seek medical consultation, resulting in an accurate diagnosis; second, even though great vessel invasion makes R0 resection difficult, the disease is sensitive to chemoradiotherapy.

Various treatments for mediastinal seminoma aim for complete cure rather than just symptom relief. Generally, most patients undergo chemotherapy and radiotherapy and receive BEP, as do patients with testicular seminoma. R0 resection is difficult to perform because of tumor invasion into adjacent mediastinal structures, with only 12.5% of patients undergoing such procedure in previous studies [10]. In our study, 33.3% of patients underwent R0 resection, showing good prognosis postoperatively. The postoperative disease control rate was reported as 90-100% in Chinese patients [12]. However, these findings indicate that R0 resection might not be associated with survival in mediastinal seminoma, unlike in testicular seminoma, probably because of a favorable prognosis and sensitivity to chemoradiotherapy.

Similar to testicular seminoma, mediastinal seminoma also demonstrates a high sensitivity to chemotherapy and radiotherapy. In this study, 92.6% and 59.3% of patients received chemotherapy and radiotherapy, with response rates of 85.0% and 100%, respectively, compared to those (100% and 90%, respectively) reported previously [12]. Furthermore, response rates for surgery alone, radiation alone, and chemotherapy alone were reported as 90.0%, 80.0%, and 83.3%, respectively [12]. Thus, the disease is sensitive to all three traditional treatments. The other response rates reported were: surgery+radiation, 91.7%; surgery+chemoradiotherapy, 90.0%; chemoradiotherapy, 100%; and surgery+chemotherapy, 100%.[12] Our study also used different modes of combined therapies, and all of them achieved favorable results.

Unlike routine chemotherapy regimens, radiation is delivered in different doses (25.2-56 Gy). In one study, the patients received 2 Gy × 30 fractions [11]. Comparing this finding with our finding revealed no significant difference in either survival or response rate, which may be due to high chemoradiosensitivities. Furthermore, a dose of 45 Gy might be a reasonable choice when considering the patient's quality of life as well as reducing the toxicities in long term.

In this study, the toxicities were tolerable. Hair loss was the most common toxicity probably because of the use of VP-16. Due to the special location of this disease and the delivery of bleomycin, we monitored for radiation-induced pneumonitis (RP). Only five patients were diagnosed with grade 1 RP, and no severe RP was observed because of both the reasonable radiation dose and the utilization of modern radiation techniques. Although there have been no cardiac-related adverse events documented, a long-term follow-up for cardiac toxicities is necessary because the heart is one of the adjacent organs.

In 2015, our institution carried out a retrospective study to investigate the clinical characteristics and outcomes of patients with primary malignant mediastinal non-seminomatous germ-cell tumor (MMNSGCT). Compared with that study, our study achieved better OS (100% vs. 49.2%) and PFS (100% vs. 32.8%) [13]. The result of the comparison is also consistent with that of previous reports [3,14,15]. A series of small combined studies also compared the OS of the two different types of mediastinal germ-cell carcinoma. The studies showed that patients with seminomas achieved a better 5-year OS than those with nonseminomas (87.0%-100% vs. 36.7%-83.0%), although not all the studies showed statistical significance due to limited sample size.

In previous small-scale studies and case reports, the 5- and 10-year OS of patients with primary mediastinal seminomas ranged from 87% to 100% and from 75% to 100%, respectively[2-4,10,11,15]. One study also showed a 5-year LRFS of 82.1%. These findings are consistent with our findings. None of the patients in our study died of seminoma at the last follow-up. Despite the cumulative 10-year risk of testicular malignancy of 10.3% after a diagnosis of extragonadal germ-cell tumor[16], no study patient showed testicular invasion or metastasis at the last follow-up. Thus, the prognosis of patients with primary mediastinal seminoma was generally good. Local relapse and distant metastasis were low after treatment.

To our knowledge, this is the largest study focusing on mediastinal seminomas. We found an association between PFS, DMFS, and Masaoka stage. Most of the patients in this study underwent modern radiation methods and could represent modern real-world data. Our findings could provide a basis for future treatment delivery in patients with primary mediastinal seminomas.

The study has a few limitations. First, different treatment regimens comprising various therapeutic agents were used with no definite guidelines. Second, certain components of the IHC test were not possible in some samples because of the long investigation period and deterioration in storage conditions. Finally, we did not have enough time to evaluate late toxicities due to the limited follow-up period.

Conclusion

In conclusion, this study revealed that mediastinal seminomas were frequently diagnosed as large tumors, were in the anterior mediastinum and prevascular region, and always invaded the great vessels. We also found that primary mediastinal seminomas were sensitive to chemoradiotherapy and patients with the disease could achieve a good prognosis, with moderate toxicities. Moreover, the treatment outcomes of seminomas were like its gonadal counterpart. Future studies with longer follow-up periods are required to further assess late toxicities from treatments.

List Of Aabbreviations

BEP, bleomycin, etoposide, and cisplatin; CR, complete response; CT, computed tomography; CTV, clinical target volume; DMFS, distant metastasis-free survival; GTV, gross tumor volume; hCG, human chorionic gonadotropin; IASLC, International Association for the Study of Lung Cancer; LDH, lactate dehydrogenase; LRFS, local-regional relapse-free survival; OS, overall survival; PFS, progression-free survival; PR, partial response; RP, radiation-induced pneumonitis; SVC, superior vena cava; SVCS, superior vena cava syndrome

Declarations

Ethics approval and consent to participate

This study was approved by the institutional ethics committee of the Cancer Hospital, Chinese Academy of Medical Sciences.

Consent for publication

Written informed consent for publication was obtained from all participants.

Availability of data and materials

The data and materials were available by sending email to the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YZ and BC designed the study, interpreted the patient data, collected the follow up information and wrote the manuscript. ZZ and YL designed the study, did the statistical work and modified the manuscript. KL, XF reviewed the radiologic and pathological data. QF, JL, YG, JL, ZX and SW performed the treatment and analyzed the data. All authors read and approved the final manuscript."

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Figures

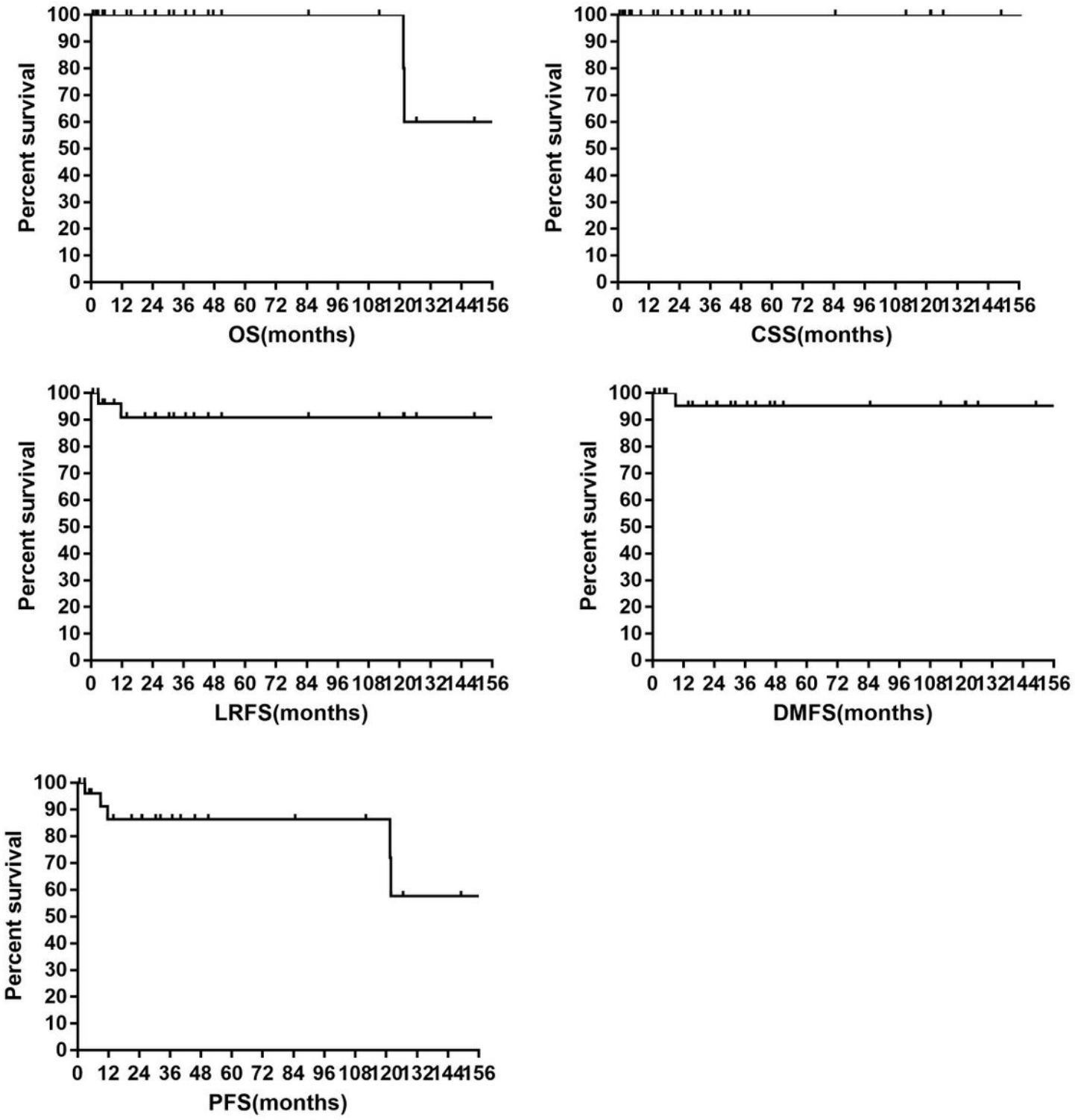

Figure 1

Overall (A), cancer-specific (B), local regional-free (C), distant metastasis-free (D), and progression-free (E) survival

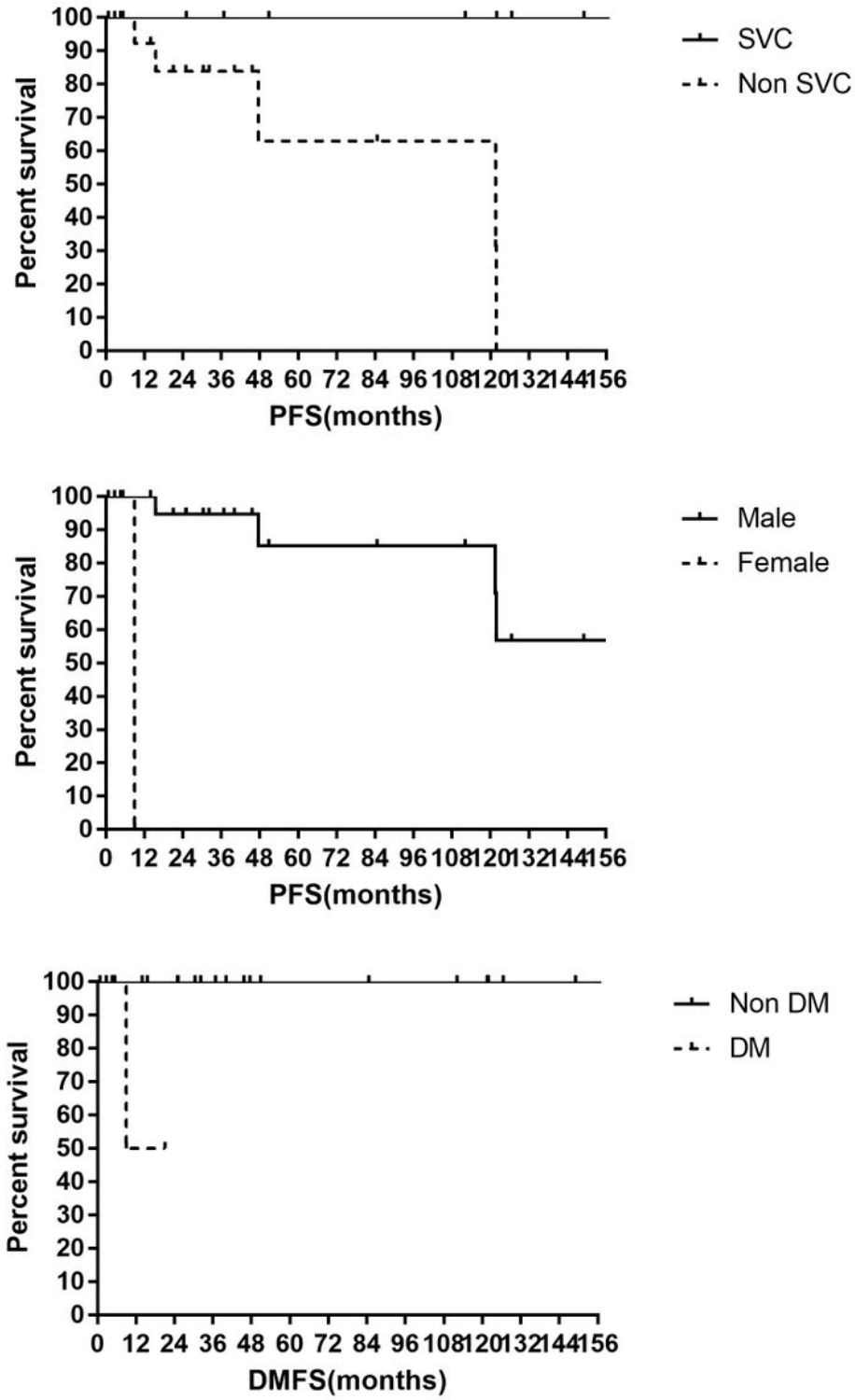

Figure 2

Progression-free survival of patients with and without superior vena cava (A) and men and women (B) and distant metastasis-free survival of patients with or without distant metastasis at primary diagnosis (C)

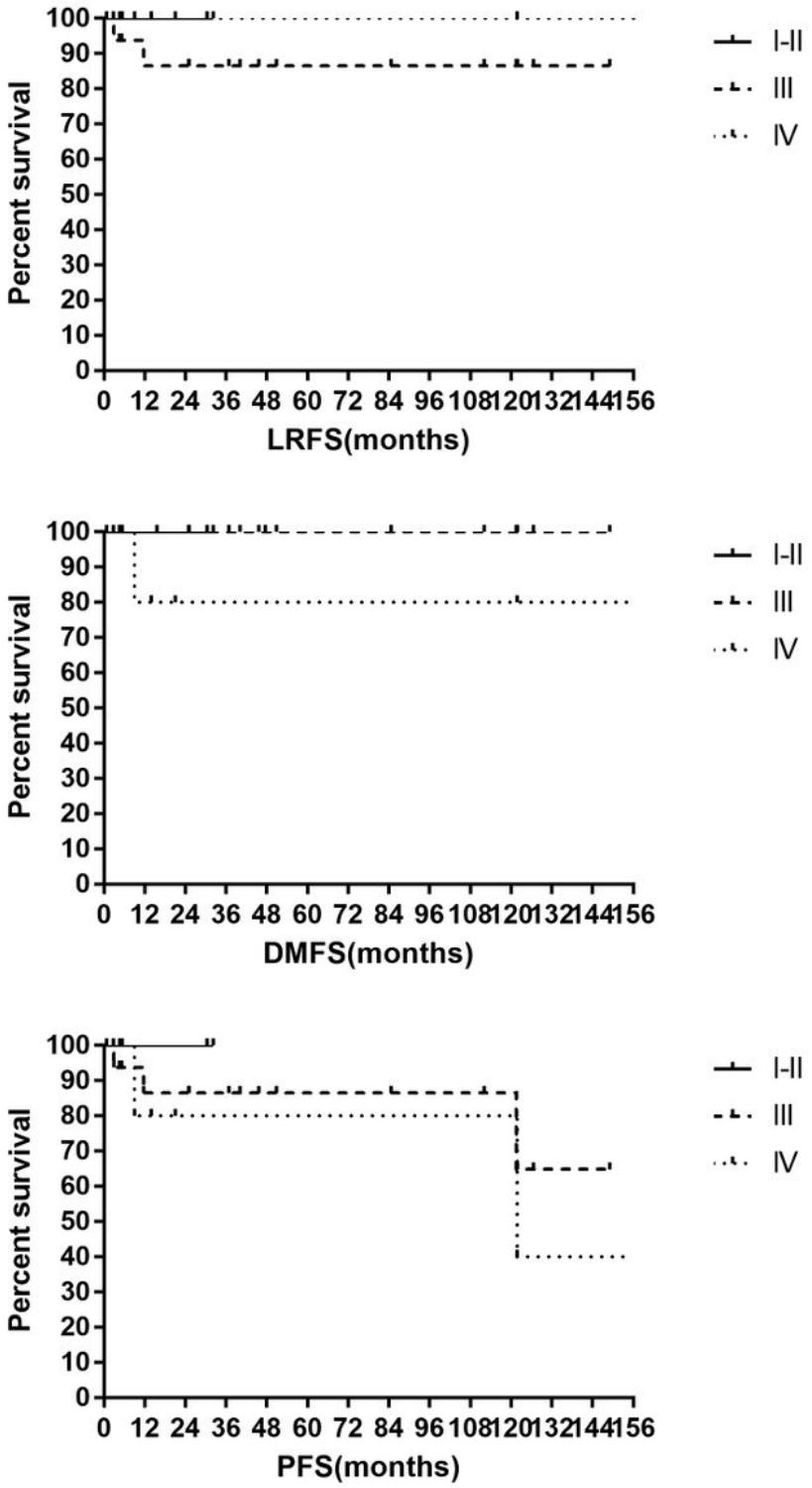

Figure 3

Masaoka stage and local regional relapse-free (A), distant metastasis-free (B), and progression-free (C) survival